

*Extracted for  
Executive Summary*  
**Central Plant Master Plan**

for  
**Fort Carson, Colorado**

Contract No. DACA 45-78-C-0106

Prepared for  
**U. S. Army Engineer District, Omaha**  
Corps of Engineers  
Omaha, Nebraska

1981

19971021 325

78-808-4



**Burns & McDonnell**  
ENGINEERS - ARCHITECTS - CONSULTANTS

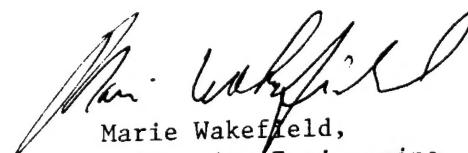


DEPARTMENT OF THE ARMY  
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September 18, 1981

U. S. Army Engineer District, Omaha  
Corps of Engineers  
6014 U. S. Post Office & Courthouse  
Omaha NE 68102

Fort Carson, Colorado  
Integrated Energy Master Plan  
Contract No. DACA 45-78-C-0106

Gentlemen:

We have completed the investigation, studies, and analyses to determine the best approach to a central plant at Fort Carson.

This report contains the data required by our contract for Increment E of the Energy Master Plan.

Sincerely,



Kenneth M. Clark, P.E.



Warren A. Roberts III, P.E.

KMC/WAR/wb

Enclosure

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### ABBREVIATIONS

Btu	- British Thermal Unit
Btuh	- Btu's Per Hour
cfm	- Cubic Feet Per Minute
gal	- Gallon (U.S.A., Liquid)
kV	- Kilovolt (1,000 Volts)
kW	- Kilowatt (1,000 Watts)
kWh	- Kilowatt-Hours (1,000 Watt-Hours)
MBH	- 1,000 Btu Per Hour
MBtu	- $10^6$ Btu = 1 mega Btu
Mcf	- 1,000 Cubic Feet
MVA	- $10^6$ Volt-Amperes
sq ft	- Square Feet

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## PART I – INTRODUCTION

PART I  
INTRODUCTION

GENERAL

The Integrated Energy Master Plan for Fort Carson, Colorado, was commissioned by the U.S. Army Corps of Engineers to obtain a complete energy analysis of Fort Carson and provide guidelines for the efficient use of energy resources. The study was divided into five increments, the first four of which, A, B, C and D were completed in October of 1980. This document, the Central Plant Master Plan, represents Increment E.

FINDINGS REVIEW

Increments A and B studied the opportunities for energy savings at Fort Carson. The Fort's goal is to reduce Btu/sf energy consumption from the base year FY75 to FY85. By 1979, a 16 percent reduction had been achieved in energy consumption leaving a 107,918 MBtu per year increment to achieve the 20 percent goal. A series of Energy Conservation Investment Projects (ECIP) were formulated covering a wide spectrum of alternatives, ranging from removing street lights to using solar energy. Based on the findings of Increments A and B, one of the two major ECIPs (EMCS or solid waste) or a combination of all the rest, except solar, should be implemented to achieve the desired energy use reduction.

Increments C and D covered the economic feasibility of installing one or more selective energy plants, a total energy plant, and a large solar energy system at Fort Carson. Also reviewed was the possibility of using solid waste as fuel for High Temperature Hot Water (HTHW) generation. The alternatives were affected by the low cost of electricity (\$.018/kwh). This low rate kept the life cycle fuel savings low; thus, the initial capital and maintenance costs could not be overcome.

#### OBJECTIVE OF INCREMENT E - CENTRAL PLANT MASTER PLAN

Increment E has investigated the options in meeting the heating needs of the approximately 125 buildings in the Cantonment Area and any forecasted additions. The primary objective has been to formulate a plan such that future heating plant needs will be satisfied by the most economical means, based on future fuel constraints.

#### SCOPE OF WORK

Through a logical progression of analyses, this study has determined the feasibility of converting fuels from gas to coal, expanding the system served and siting a new power plant. At the time of this writing the decision had been made to interconnect the old and new hospital plants via underground pipelines. Part III deals with the economic aspects of this decision by evaluating this and other cross-connection

possibilities. Connecting the old hospital complex with the new hospital will occur regardless of which power plant option is selected. The feasibility of interconnecting one of the three possible coal-fired heating plants with Building 1860 was studied.

Part IV provides background information concerning the existing and potential power plants which could serve the Cantonment Area. The Medium, either HTHW or steam, and the installed capacity are discussed along with the physical facilities of each plant. The energy demands to be placed on these power plants and the recommended heating system to be used are analyzed in Part V. Taken into consideration are potential additions to the system. The buildings were divided into two classifications: those requiring heating and cooling, and those requiring only heating. In order to meet the heating requirements of the buildings described in Part V, a detailed analysis of the HTHW distribution system, from Building 1860 to the connected load was conducted in Part VI. The impact of planned additions upon the system, with regard to its capacity, was analyzed and a determination made as to the availability of excess capacity within the existing central plant (Buildings 1860 and 1964). With the overall objective of this Increment being to provide guidance for decisions concerning energy use at Fort Carson, Part VII provides an analysis of the viability of constructing a coal-fired power plant to serve the Cantonment Area plus additional

buildings. A comparison of the costs associated with a coal or natural gas power plant was conducted with various boiler layouts investigated. Three potential sites were reviewed with analyses undertaken concerning possible construction at each site. A brief analysis of the absorption chiller system was undertaken with recommendations made regarding chiller requirements.

#### DATA SOURCES

Much of the background information concerning the future development and energy needs of Fort Carson was supplied by the Corps of Engineers. For FY81 projects, design analysis packets and construction drawings were issued. For FY81 through FY87, the Fort Carson Master Plant (Bibliography reference 3), which contained brief project descriptions and a master planning map, were used.

In many cases, the various data sources which were reviewed contained conflicting statements and were subject to revision. To accomplish the work, assumptions were made to clarify the various conflicts. These assumptions, regarding future projects, were based on the characteristics of existing portions of the Fort, studied in previous Increments and on professional judgment. All assumptions are documented herein.

\* \* \* \* \*

## PART II – SUMMARY & CONCLUSIONS

PART II

SUMMARY AND RECOMMENDATIONS

GENERAL

Several options exist to meet the energy needs of the Cantonment area at Fort Carson. Analyses of various fuel systems, piping networks and plant locations were conducted to provide guidance to future decision makers.

HEATING PLANTS CROSS-TIE

The first area investigated was several additions, via underground pipelines, to the HTHW system. The connection between the old hospital and new hospital was evaluated. Table II-1 presents the results of four cross-tie connections including costs, distance, capacity, size and comments.



Table II-1  
Comparison Sheet  
Proposed Interconnections

Termination Points	Estimated* Cost (1980)	Point-to- Distance (ft)	Mega Btuh Capacity	Pipe Size (Inches)	Comments
Bldg. 6290 to New Hospital	1,965,000	3,600	30	8	Replacement of some boilers in Building 6290 necessary.
Bldg. 1860 to Bldg. 6290	2,916,000	8,200	30	10	Enlarged nitrogen pressurization system at Bldg. 1860 required.
**Bldg. 1860 to Central Coal Plant	3,927,000	2,600	150	18	Enlarged nitrogen pressurization system at Bldg. 1860 required.
**Bldg. 1860 to North Coal Plant (Alternate)	3,927,000	7,250	101	14	Extension of existing HTHW network, enlargement of nitrogen pressurization system & minor pipe modifica- tions at Bldg. 1860 required.
**Bldg. 1860 to South Coal Plant (Alternate)	1,716,000	4,800	60	10	Enlarged nitrogen pressurization system at Bldg. 1860 required.

\* Includes cost of pipeline plus necessary work in central plants.

\*\*No more than one of these options will be implemented.

As Table II-1 indicates, should cross-ties be developed between Building 1860 and the power source locations, some work will have to be done to enlarge the nitrogen pressurization system at Building 1860. The proposed characteristics of these cross-ties are listed in Table II-2.

Table II-2

Characteristics of Proposed Pipelines

Medium: HTHW (max temperature 375 degrees F, max operating pressure 275 psi)

Construction: Direct-burial, preinsulated, conforming to Army TM5-810-2.

Schedule 40 steel inner carrier surrounded by calcium silicate insulation and a 10-gage steel outer conduit. Outer conduit to have corrosion-proof, waterproof coating.

Joints of inner pipe and outer conduit to be welded.

Expansion: Expansion loops spaced at 200-foot (approximate) intervals. Anchor blocks to be spaced at 200-foot (approximate) intervals.

Access: Manholes, for access to valves and drain plugs, to be spaced as required.

Depth: Four to five feet.

FUTURE BUILDING ENERGY ALTERNATIVES

Seven heating systems were examined to ascertain which would best meet the existing and future needs of the various building groups in the Cantonment area. These systems were:

1. Natural gas-fired HTHW plant.
2. Coal-fired HTHW plant.
3. Individual natural gas boilers.
4. Individual electric systems.
5. Heat pumps.
6. Solar-assisted heat pumps.
7. Heat storage systems.

A representative building was selected to illustrate the process which was used to quantify the benefits and costs of the various systems. The conclusions drawn and recommendations made are based upon detailed analyses of buildings or groups of buildings. For discussion purposes, the buildings were divided into groups. The recommendations for each building group are contained in Table II-3. The buildings within each building group are listed in Table V-9.

While each building must be analyzed on its own merits to determine the optimum heating system the following general comments apply. The natural gas-fired HTHW plant will not be the most economical except when the building is very close to the HTHW main. The coal fuel HTHW plant will offer fuel savings, but will offer life cycle savings only when relatively close to the HTHW main (270 feet for the Five-Company Administration and Storage Building, FY81-316). Individual natural gas

boilers will have the lowest life cycle costs for most buildings further from the HTHW main. Individual electric systems will normally have a slightly higher life cycle cost than natural gas, but with lower capital costs may have the advantage when a short life is expected. For example, electric resistance heat would probably be the choice in a building planned to be connected to the coal HTHW system several years later. Heat pumps have a very slightly lower life cycle cost over 25 years than electric resistance heat-only systems, but should definitely be looked at if air conditioning is required. Solar assisted heat pumps and heat storage systems are generally not economical.

Table II-3

## Recommended Heating Systems

<u>Building Group</u>	<u>Recommended System</u>
Motor Repair Shops	Gas or Electric
NW Existing Buildings (W of N end of Banana Belt)	HTHW
W Existing Buildings (S of NW Existing Buildings)	HTHW
NE Industrial Buildings (Future Buildings Near Bldg. 8000)	Gas or Electric (HTHW)*
NW Industrial Buildings (Future Buildings N of Banana Belt)	Gas or Electric (HTHW)*
FY 83 Buildings	
LI325 Admin. & Supply	HTHW
329 Admin. & Supply	HTHW
All Others	Gas or Electric
(Future Building outside HTHW Service Areas)	

\*These buildings become feasible for HTHW when the 150-mega Btuh Coal Plant is considered.

The analyses determined that the life cycle cost difference between using natural gas heat or electric heat was insignificant. For those buildings where either option is recommended the final choice will have to be made based on noneconomic factors. The HTHW option generally ranked just above or just below the gas or electric option. HTHW will generally be best for buildings less than 250 feet from the existing network.

### HYDRAULIC AND LOAD ANALYSIS

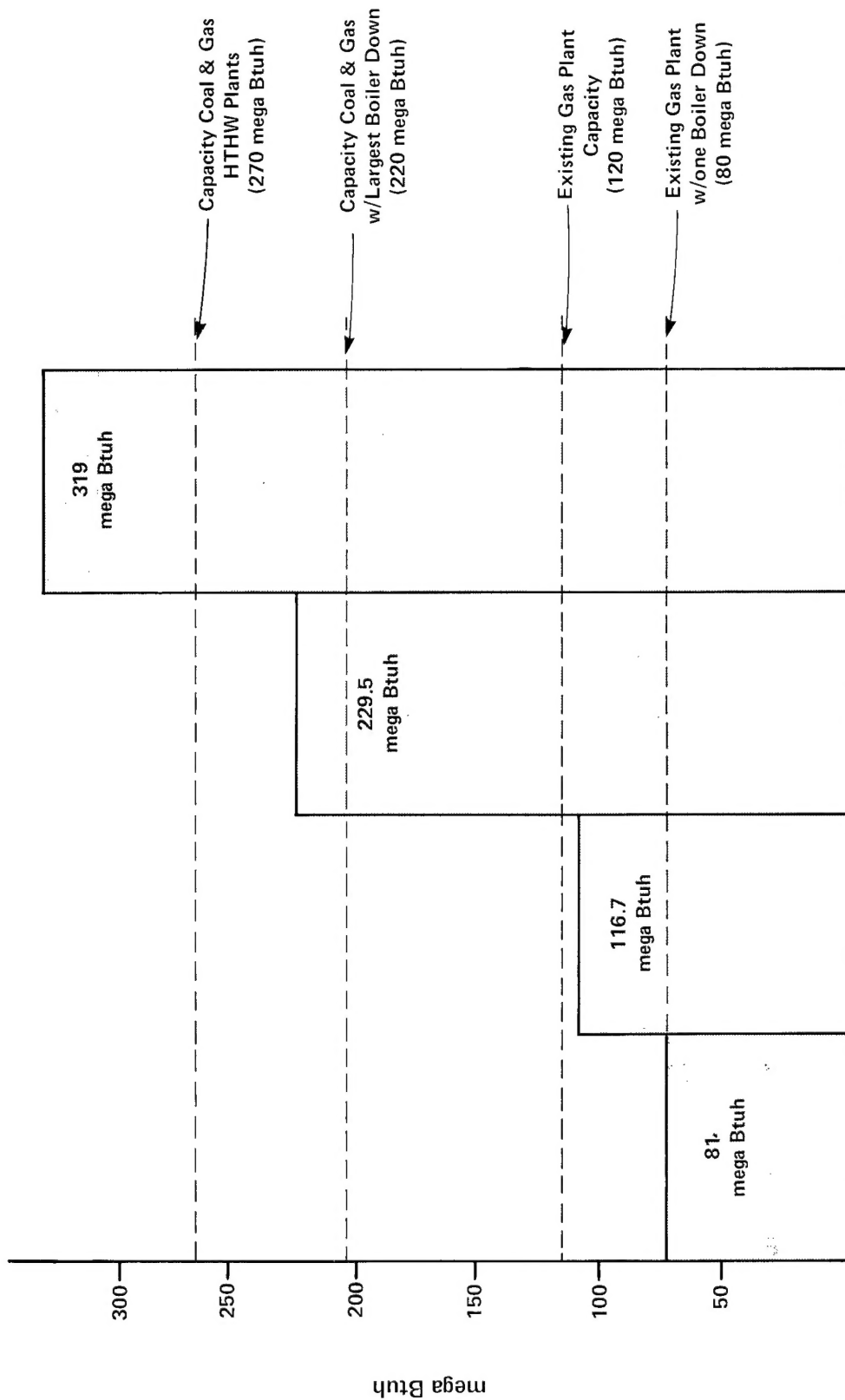
This section has taken the results of the Building Energy Alternatives, plus existing energy usage plans, and analyzed the demands placed on the HTHW distribution system from the central plant (Building 1860) to the connected load. Construction through FY 85 was added to the existing network and several computer simulations were run to ascertain the adequacy of the pipe network. By means of these simulations it was determined that the current distribution system is adequate to handle existing and forecasted loads with some minor modifications. These modifications include upsizing the 2-1/2-inch branch to Building 1160 to four inches. Overall, the limiting factor on the HTHW system will be the eight-inch and larger line in the existing system prior to the new eight-inch branch to the T.O.E. Additional loads in the new industrial area will require a new line from the Building 1860 HTHW plant.

### BOILER CAPACITY

The HTHW plant, while meeting forecasted demands, will have no excess capacity and no backup. A boiler load analysis revealed that peak demands placed on the system are about 50 percent of the total building design capacity. With the 1860 plant having three 40-mega Btuh boilers for a total of 120 mega Btuh, it will be able to meet the expected peak load (after FY 85 construction) of 116.7 mega Btuh, but will not have any backup. If one boiler is down, there will be sufficient heat

production remaining, at design conditions to heat all buildings to only 43 degrees F. For short outages (15 hours or less), indoor temperatures should not drop to the 43-degree F level. See Table II-4 for a comparison of demand versus plant capacity.

These forecasted demands will be affected by the installation of any of the proposed ECIP projects. While all will reduce total annual energy, some, such as EMCS and night setback, will actually increase peak demand. Others will reduce the peak demand on the system. The solid waste plant alone, if properly scheduled, could reduce the peak demand on the gas plant by 10 mega Btuh.



BEYOND  
FY87

NEW HTHW  
CONNECTIONS

FY79-  
FY87

EXISTING  
(79-80 PEAK)

Peak Demand

Table II-4  
COMPARISON OF EXISTING  
& PROJECTED DEMAND TO  
CAPACITIES OF VARIOUS  
PLANT CONFIGURATIONS

**Burns & McDonnell**  
Engineers-Architects-Consultants



#### CHILLER CAPACITY

Total chiller capacity will not be a problem, but there will be no backup capability if one chiller goes down. To meet chilled water requirements, Building 1864 has three 1,200-ton chillers for a total of 3,600 tons. The expected peak chilled water requirement, after FY 85 construction, will be 3,174 tons.

#### CENTRAL PLANT MASTER PLAN

With the existing heating and chiller systems being fueled by natural gas (oil backup) and having the potential for capacity and backup capability problems, an analysis was undertaken to determine the feasibility of constructing a 150-mega Btuh coal-fired power plant. The recommended size of the plant (150 mega Btuh) was determined following economic analyses of plants ranging from 60 mega Btuh to 150 mega Btuh. The addition of the Northeast and Northwest Industrial Buildings to the HTHW loop did not show a life cycle savings connected to a 120-mega Btuh facility, but the combination of this addition and the expansion of the coal-fired HTHW plant to 150 mega Btuh showed a life cycle savings of \$1,260,000. It was determined that three 50-mega Btuh HTHW generators would be optimum, because the capital costs would be lower than five 30-mega Btuh boilers while still maintaining a low fire capability for low demand periods. Another possibility would be two 60-mega Btuh generators and one 30-mega Btuh generator. This option would not

significantly change capital costs and would allow better low fire flexibility. One disadvantage would be the risk of slightly less reserves when one large boiler is lost.

To provide backup and additional peak-load capability, it was assumed natural gas will continue to be available. Due to the high capital costs of coal versus gas equipment, this dual system is more economic than straight coal. Providing coal capacity of about 50 percent of peak demand will allow coal to supply about 85 percent of the annual fuel requirements. A coal plant designed for 100 percent of the demand on that plant will have a higher life cycle cost than a similar natural gas plant. For a coal plant to be economical at Fort Carson it must be base loaded with existing natural gas boilers used for peak demands and backup.

The economic analysis indicated that if the coal-fired central plant is constructed without long-term coal storage and rail delivery, it has a lower life cycle cost than the natural gas version (\$8,955,000 net life cycle savings). This savings, compared to a total capital investment of almost \$33,000,000 justifies the project. A drawback is that total Fort energy usage will increase by about 10,000 mega Btuh per year due to the lower efficiency of coal boilers. The storage and rail delivery options could be added, at a later time, should they become feasible.

Once the cost-effectiveness of the plant was determined, a siting study was undertaken. Two sites were identified as having high potential. An additional south site was investigated, but not feasible. The north site, which was used in the Nakata Study and the Fort Carson Master Plan, entails slightly lower site costs and less distribution piping costs (\$56,000). The central site has advantages of its more central location, reduced travel time between Building 1860 and the coal plant, a less restricted site area, and will not require flow reversal in the main HTHW line. We recommend the central site due to the small cost differential and the listed advantages.

While air pollution needs to be considered, we anticipate no major problems with air quality permitting. Some offsets (existing source reductions) for particulate and carbon monoxide emissions will be required.

An analysis of the absorption chillers revealed that if the coal plant is not built, a further study to convert to electrical centrifugal should be undertaken. If the coal plant is built, the existing chiller plant is adequate.

\* \* \* \* \*